RESEARCH HIGHLIGHT

May 2011 Technical Series 11-100

The Impact of Gas Fireplace Operation on Winter Energy Consumption and House Temperatures

INTRODUCTION

Gas fireplaces are prevalent in homes across Canada. In the 2007 Survey of Household Energy Use (NRCan, 2007) almost a quarter of all homes (23%) reported having a gas-burning fireplace, up from a reported 19% in 2003. Of these homes, 22% reported using the fireplace every day during the heating season.

When a fireplace is operated close to the house's central thermostat, the heat introduced by the fireplace can cause the heating system to delay its normal cycle of operation – affecting energy consumption and temperatures in the home. The purpose of this set of experiments was to examine the impact of operating a gas fireplace in an R-2000 house: including the interaction of the fireplace and pilot light with the central thermostat, the impact on energy consumption for heating, and changes in room air and surface temperatures.

RESEARCH PROGRAM

The evaluation of the impact of gas fireplace operation was carried out at the Canadian Centre for Housing Technology[1] (CCHT) in Ottawa, Canada. The unique nature of the CCHT twin house facility allows not only the examination of energy savings but also provides a complete picture of house performance.

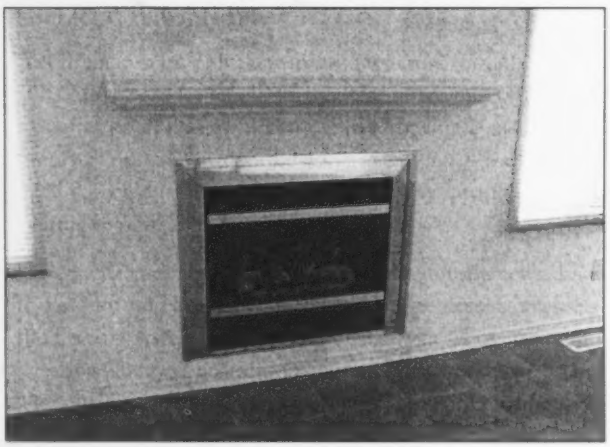

Figure 1 The Test House Fireplace

METHODOLOGY

The fireplace in this study was a direct-vent, zero clearance, natural gas fireplace with a standing pilot light and 48 W circulating fan. The fireplace had a maximum input of 20,000 Btu/h with a measured steady state efficiency of 76%. The fireplace was located in the main floor family room, recessed into the North wall (see Figure 2).

[1] The Canadian Centre for Housing Technology is jointly operated by the National Research Council, Natural Resources Canada, and Canada Mortgage and Housing Corporation. This research and demonstration facility features two highly instrumented, identical R-2000 homes with simulated occupancy to evaluate the whole-house performance of new technologies in side-by-side testing. For more information about the CCHT facilities please visit http://www.ccht-cctr.gc.ca.

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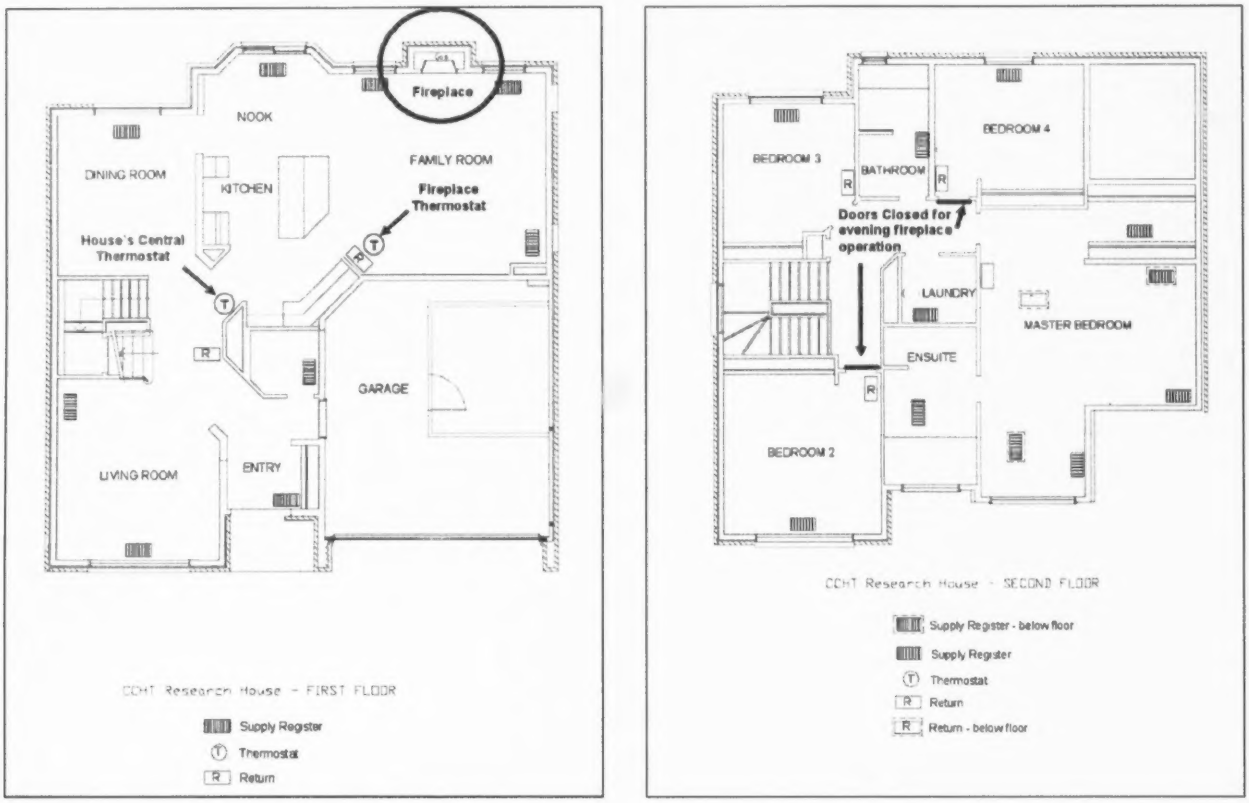

Figure 2 CCHT house floor plans showing fireplace location

To determine the impact of fireplace operation, the CCHT houses were first benchmarked under identical conditions, and then the fireplace was operated in the "Test" house. In benchmark heating conditions the central thermostats were set to 22°C, a high-efficiency condensing gas furnace (94% measured steady state efficiency) provided the heat. The furnace fan provided continuous low speed air circulation when not in high speed heating mode.

During the experiment, the "Reference" House remained in benchmark configuration while the following fireplace configurations were explored in the Test House:

- Evening fireplace operation from 18:00 – 24:00 (6:00 P.M. – 12:00 A.M.), with the furnace fan providing continuous air circulation when not in high speed heating mode.
- Evening fireplace operation from 18:00 – 24:00 (6:00 P.M. – 12:00 A.M), with the furnace fan shut off in both houses (no continuous air circulation) when not in high speed heating mode.
- Continuous fireplace operation (24 hours/day), controlled by a dedicated thermostat set 2°C above the setpoint of the central heating system thermostat, with the furnace fan providing continuous air circulation when not in high speed heating mode.
- Pilot light operation only (24 hours/day) with the furnace fan providing continuous air circulation when not in high speed heating mode.

Fireplace gas and electrical consumption, furnace gas and electrical consumption, drywall surface temperatures, and room air temperatures were collected throughout the experiments and benchmarking.

FINDINGS

Increased Total Heating Energy Consumption due to Fireplace Operation

Fireplace operation in the evening resulted in an increase in natural gas consumption for both cases: with and without continuous air circulation by the furnace fan. However, results showed no significant difference in gas consumption trends between these two modes of fan furnace operation during the experiment. Average consumption results over the experiment period are given in Table 1, and sample days of consumption data are shown in Figure 3. Over the experiment period with and without continuous circulation, the fireplace consumed on average 144 MJ/day of natural gas, decreasing furnace consumption by 106 MJ/day (39%), for an average increase in total natural gas consumption of 38 MJ/day (16%).

The main difference between the experiments with and without continuous air circulation was the impact on furnace fan electrical consumption. This in turn affected total heating consumption. Without continuous fan operation, the furnace consumed on average 4.12 kWh/day circulation for the experiment period, while the furnace would be expected to consume approximately 10 kWh/day with continuous circulation. The reduction in fan motor consumption alone would be expected to impact house heating load, since reduced fan motor operation would release less heat to the supply airstream. The reduced air circulation would also be expected to impact air quality in the home since the furnace fan is used to distribute fresh air from the heat recovery ventilation system - this was not measured in this project.

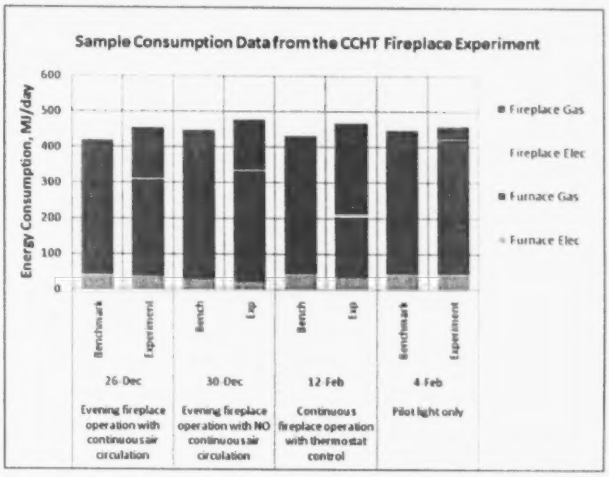

Figure 3 Sample Consumption Data from the Fireplace Experiment

Operation of the fireplace 24 hours per day by thermostat control resulted in a large reduction in furnace operation – due to the close proximity of the fireplace to the central heating system thermostat of the house. On average, the fireplace consumed 249 MJ/day of natural gas and 1.28 kWh/day of electricity, and reduced furnace consumption by 208 MJ/day (59%) of natural gas and 2.13 kWh/day of electricity for an overall increase of 38 MJ/day (10%) in total heating energy consumption. Despite this increase in consumption, taking efficiencies into account, the total heat output of the furnace and fireplace combined was 2.3% lower.

Table 1 Average Daily Consumption for Heating during the Fireplace Experiment

	Gas (Furnace and Fireplace)			Electrical			Total Energy (Gas and Elec.)		
Mode of Operation	No fireplace, MJ	With fireplace, MJ	Difference	No fireplace, kWh	With fireplace, kWh	Difference	No fireplace, MJ	With fireplace, MJ	Difference
Evening fireplace operation with continuous air circulation	325	365	16%	10.92	10.06	-8%	365	401	13%
Evening fireplace operation with no continuous air circulation	294	330	15%	5.82	4.12	-31%	315	345	12%
Continuous fireplace operation with thermostat control	354	395	12%	11.28	10.43	-8%	395	433	10%
Pilot light only	345	364	6%	11.20	11.01	-2%	[illegible]	404	5%

Reduced Second Floor Room Temperatures

Evening operation of the fireplace heated the family room well above the temperature setpoint of the furnace thermostat (22°C), exceeding 25°C at times during the experiment. During evening fireplace operation, air temperature in bedrooms on the second floor dipped by as much as 2°C, resulting in up to an 8°C difference in temperature between rooms, as shown in Figure 4. This effect was most pronounced in the bedrooms furthest away from the fireplace location. Temperature results were similar for both the continuous and non continuous air circulation modes. This may be an indication that the furnace fan in continuous air circulation mode was not effective at moving heat from the fireplace room to the second floor.

Operation of the fireplace by thermostat control held the family room 2°C above the setpoint of the house central heating system thermostat. This mode of operation also resulted in temperatures on the second floor being 1 to 2°C cooler due to fireplace operation.

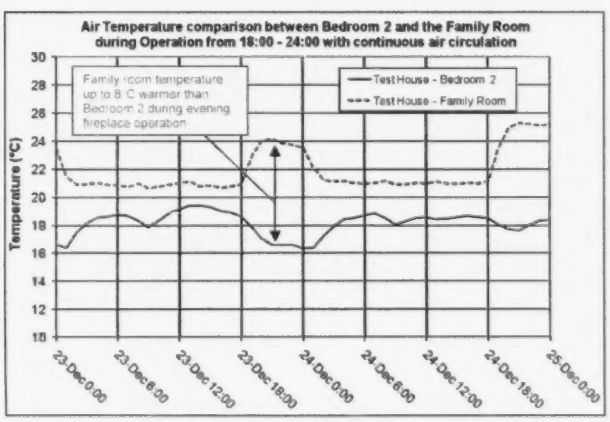

Figure 4 Air Temperatures in Bedroom 2 and the Family Room during Evening Fireplace Operation

Slightly Cooler Surface Temperatures

Despite the daily dips in second floor air temperature associated with evening fireplace operation, minimal differences in surface temperatures were measured on the second floor of the house – the biggest difference was noted on the exterior wall of the bedroom 2 closet, where the minimum surface temperature was reduced by 0.7°C due to fireplace operation. The lowest temperature reached at this location was 12.8°C. At this temperature, air at 21°C with 59% humidity would be expected to condense. Effects at the other locations were minimal. While there were some fluctuations in surface temperature recorded during the experiment, small reductions in temperature due to the furnace shutting off during the 6 hours of fireplace operation were compensated by regular furnace operation throughout the remaining 18 hours of the day. A lower house setpoint temperature or daily house thermostat setback in combination with fireplace operation would reduce furnace on time, and could potentially lead to lower surface temperatures.

Impact of Pilot Light Operation

The operation of the pilot light alone also impacted furnace operation. The pilot light consumed on average 38 MJ/day natural gas, and resulted in an average reduction in furnace gas consumption of 19 MJ/day (6%) during the experiment period, for a total gas consumption increase of 19 MJ/day (6%). The total impact on heating energy (electrical and gas) consumption was an increase of 18 MJ/day (5%) due to pilot light operation.

The impact of pilot light operation on room temperatures was minimal: a ~0.3°C temperature increase in the family room (where the fireplace was located) and a small temperature decrease on the second floor of the house (~0.2°C) were detected.

LIMITATIONS OF THIS STUDY

The impact of fireplace operation will be different for all different houses and mechanical setups. Care should be taken in applying these results to other homes, due to certain attributes of the CCHT facility.

Some of the issues that should be kept in mind include:

- The CCHT houses feature an open plan layout with the fireplace in close proximity to the central thermostat. A closed layout and/or the fireplace located far from the thermostat would minimize interactions with the central heating system.
- The CCHT houses are built to R-2000 standards; therefore, they hold heat better than older houses. Fireplace operation in a house with lower quality windows and insulation could lead to lower air and surface temperatures in locations far from the fireplace.
- The houses feature a heat recovery ventilator that runs continuously, and uses the furnace fan in continuous circulation mode to distribute fresh air into the house while losing little heat. This is a feature of R-2000 houses due to their high airtightness, and not common in older "looser" houses where air exchange occurs without mechanical help and without heat recovery.
- The CCHT houses are unfurnished. In a furnished house, the contents could affect the time taken for the house to adapt to changes in temperature.
- The house thermostat setting during the fireplace experiments was 22°C, a lower setting, or a thermostat setback with fireplace operation could result in lower room temperatures in locations far from the fireplace.

CONCLUSIONS/IMPLICATIONS FOR THE HOUSING INDUSTRY

Through these experiments, fireplace operation was shown to have a significant impact on increasing total house heating energy consumption and lowering air temperatures in far away rooms. The impact of fireplace operation will be different for all types of homes and mechanical setups. For this reason, it should be noted that these findings are valid for the CCHT twin-houses and an energy model should be used when projecting the results to other situations.

The increase in overall gas consumed when the fireplace is used is in large part due to the lower efficiency of gas fireplaces compared to the efficiency of the high-efficiency condensing gas furnace (76% and 94% respectively in this experiment).

This project highlights the need for careful consideration of thermostat placement. When the thermostat is in proximity of the fireplace, fireplace operation can reduce the thermostat's call for heat, and result in substantially cooler temperatures in distant rooms. The large temperature swings that would be experienced by someone moving from room to room in the home could have a negative impact on comfort.

Even when the fireplace was not in operation, the pilot light alone showed some influence on the central heating system, and increased total heating energy consumption. An intermittent or automatic electric ignition system would eliminate the need for a pilot light, and would result in substantial energy savings.

A full report on this project is available from the Canadian Centre for Housing Technology.

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Housing Research at CMHC

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Printed in Canada
Produced by CMHC 26-05-11

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